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Measuring Patient Preferences for Colorectal Cancer Screening Using a Choice-Format Survey

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ABSTRACT

Objective: Colorectal cancer (CRC) screening uptake remains poor. Until we understand patient motivation and preferences for undertaking screening, it is unlikely the uptake will be optimal. Our objective is to examine patient preferences for CRC screening modalities and uptake rates using utility-based methods.

Methods: The preference survey was mailed to a random sample of Canadian subjects aged 40 to 60 years from a primary care network. A fractional factorial experimental design maximized D-efficiency and included four blocks with 12 choice tasks in a conditional two-step design, two-alternative discrete choice format with five screening attributes (process, pain, preparation, sensitivity, and specificity). Bivariate probit regression analysis was used to estimate patient preferences for attributes, choice probabilities for alternative modalities and expected rates of uptake.

Results: Five hundred forty-seven of 1047 surveys were returned. Almost 30% of respondents preferred no screening. The most preferred test attribute levels were noninvasive process (e.g., CT), no preparation, no pain, 100% specificity, and 90% sensitivity. Accuracy-related attributes were more important than test process-related attributes. Virtual colonoscopy was the most preferred, followed by colonoscopy, barium enema, sigmoidoscopy, and fecal DNA testing, based on simulated choice probability estimates. Fecal occult blood testing (FOBT) was least preferred. Adjusted screening uptake rate estimates showed the greatest impact (42% increase) would be achieved if all CRC screening modalities were available rather than FOBT alone.

Conclusions: Our findings emphasize the important role of patient preferences for no screening and in selecting alternative CRC screening modalities. CRC screening implementation in Canada should consider patient preferences to optimize uptake.

Keywords: colorectal cancer screening, conjoint analysis, discrete choice experiment, patient preferences, stated preferences.

Background

Colorectal cancer (CRC) accounts for approximately 13% of all cancers diagnosed in Canada. Because of its high incidence, long precancerous phase, and more favorable prognosis at earlier stages, CRC is considered a promising target for population-based screening [1]. Several screening modalities can be adopted, including fecal occult blood testing (FOBT), flexible sigmoidoscopy (SIG), colonoscopy (COL), and double-contrast barium enema (DCBE). Recent economic analyses suggest that all of these strategies meet conventional criteria for cost-effectiveness [2–4].

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In the United States, CRC screening is recommended using any of the available methods. In contrast, no Canadian province has a formal CRC screening program in place [5]. Several Canadian provinces and organizations are actively considering screening programs [6–9]. Thus, it is important to understand preferences for screening in the Canadian population where relatively few people have had CRC screening.

A key factor driving the success or failure of any screening program is patients' willingness to undergo the screening test. Even in the United States, where all available CRC screening modalities are promoted and screening is reimbursed, uptake is poor. Approximately 50% of individuals older than 50 years of age have ever been screened using any screening method [10]. It has been shown that interventions aimed at increasing knowledge do not necessarily help to increase the uptake or adherence to an intervention [11]. As such, until we understand the motivation for undertaking or choosing not to undergo CRC screening and patient preferences for alternative CRC

screening modalities, it is unlikely that CRC screening programs will be successful in optimizing uptake.

The important role of patient preferences in CRC screening, and in medical decision-making in general, has garnered increased attention [12,13]. At the same time, although there is broad recognition that providers and patients must appreciate and weigh multiple dimensions in choosing a CRC screening test, there has been little empirical work to measure or guide this process. For example, previous surveys have identified that there is substantial variation in patient preferences for CRC screening, and have examined the order of importance of various features of the modalities [14] and preferences for CRC screening programs [15], but not the magnitude of preferences for the alternative CRC screening modalities.

There are no data available about CRC screening modality preferences in Canada. As such, the objective of the current study was to measure and quantify Canadian preferences for various CRC screening tests and for a "no-screening" option using utility-based methods. In addition to identifying and quantifying the importance of the key attributes of CRC screening tests, these results may provide some insight to guide policy decisions on the implementation of CRC screening programs with respect to initial uptake. The design of this study represents a methodological advance over existing studies by using utility-based methods that include a "no screening" option so that screening uptake can be estimated from the results. This information is also timely given the current discussions about piloting and implementing CRC screening in Canada, and they are also relevant to other populations by providing more detailed information about preferences.

Methods

Choice-Format Stated Preference Surveys

Conventional strategies for CRC screening vary considerably in features of both process (e.g., invasiveness and convenience) and outcome (e.g., diagnostic error) features [13,16–21]. Process attributes are not captured by more conventional preference-based outcome measures such as the quality-adjusted life-year, which has been used previously to evaluate CRC screening [22]. Choice-format stated preference survey methods, sometimes referred to as conjoint analysis or discrete choice experiments, is a powerful technique for measuring consumer preferences for goods and services [23]. With strong roots in economic theory and design of experiments, this methodology has been adapted to evaluate health services [23–25]. It is well suited for CRC screening preferences because it is designed to measure quantitative trade-offs among multi-attribute choices, including aspects of both process and outcome. Choice-format stated preference survey results can be used to model preferences for individual attributes, determine relationships among attributes, and estimate the relative utility of combinations of attributes that represent real or hypothetical CRC screening programs. We use utility in the conventional sense of a general index of individual satisfaction. It is ordinal in the sense that the index is not scaled between zero and one and is unique under any positive affine transformation.

Undertaking a choice-format stated preference survey entails several steps: 1) identifying key attributes; 2) assigning levels to the attributes; 3) selecting the format of the survey; 4) developing scenarios that describe services defined by various combinations of attributes and levels; 5) eliciting preferences; and 6) analyzing choice data to quantify the benefit of offering more favorable testing options [25–29]. These steps provide a framework for our approach [27,28,30].

Definition of attributes. A preliminary menu of attributes was prepared through literature review and expert consultation. Focus groups were conducted using a semistructured interview guide. An extensive list of CRC screening attributes was generated by initially presenting each participant with a restricted list. This was used to stimulate the discussion about features of the test, and the moderator probed to elicit additional attributes. In a modified Q-sort exercise [31], each participant reviewed a list of 16 attributes (false negative rate, false positive rate, change in risk of cancer, risk of complications, "one-stop shopping," invasiveness of procedure, change in risk of cancer death, fear/stress from results, preparation required for testing, length of time for testing, length of time for recovery, pain, embarrassment, need for follow-up testing, how frequently the test must be repeated, cost of the test), assigned one or more points to them (using 10 self-adhesive dots, each worth one point) and discussed their choices with the group. Audiotaped sessions were transcribed verbatim by a professional transcriber and analyzed by an experienced qualitative researcher using the editing style of analysis to label text segments by theme, focus group and respondent. Major and minor themes were identified, linked to raw data and findings were summarized in text and tabular form before interpreting in light of current literature and discussions with research team members [32,33].

A series of eight of these structured focus groups helped define five attributes (process, pain, preparation, specificity, sensitivity) (Appendix A) as the most important to respondents and most relevant to policy decisions involving CRC screening modalities. It was evident from the focus groups that each of these attributes was a distinguishable feature of CRC screening modality. Focus group participants were also able to differentiate between specificity and sensitivity of the screening test.

Because the purpose of this study was to focus on uptake of CRC screening modalities, we deliberately did not consider attributes of screening programs, such as the interval to next screening and the impact on cancer mortality. In addition, we also included a cost attribute to facilitate estimating the sensitivity of uptake to possible variations in copay levels. The details of this process and the findings are reported elsewhere [34, Lohfeld et al., submitted]. The same focus groups were used to pilot test the survey to ensure that attributes were comprehensive, unique, and clearly defined.

Assignment of attribute levels. For each selected attribute, several potential values or levels were defined (Appendix A). These were chosen to represent both currently plausible values and those that might be achieved with novel screening modalities. For example, the sensitivity of COL, and DCBE for detection of CRC is at least 90% [35,36], whereas that of FOBT and fecal DNA assays is estimated by some sources to be 60% or less [35,37]. Accordingly, values from 40% to 90% were assessed in the survey.

Survey format. The survey used a conditional two-step design, in a two-alternative discrete choice format with binary responses [38]. For each choice task, subjects were first asked to identify which of two hypothetical screening modalities they would prefer (Choice 1: A vs. B) [39]. Subjects were then asked to choose between that preferred screening modality (A or B) and no screening (Choice 2). This design maximizes the information obtained on both the marginal rates of substitution among modality attributes and conditional uptake rates. An example of a choice task from the survey is provided in Appendix B.

Scenario design. The survey attributes and levels would allow 216 unique attribute combinations, excluding cost, in a full factorial design ($4 \times 2 \times 3 \times 3 \times 3$). Thus, as is common practice, a fractional factorial design was used to identify a subset of combinations that could estimate preference weights for all attributes while minimizing the number of paired comparisons [40,41]. This design was developed using the SAS Optex procedure and optimized several measures of efficiency in a general linear model [41]: 1) level balance (i.e., levels of an attribute occur with equal frequency); 2) orthogonality (i.e., the occurrence of any two levels of different attributes is uncorrelated); and 3) D-efficiency (the partworth estimates for a D-efficient design have the smallest possible standard errors, given the sample size, and number of partworths). Each scenario included two to three overlaps (attributes whose levels are the same for both alternatives).

The design allowed estimation of two attribute interactions: preparation and pain, and specificity and sensitivity based on our initial hypotheses. Neither of these interaction terms is statistically significant and is not reported here. We also included interaction terms between no screening and demographic characteristics that were chosen based on theory and prior findings.

In pilot testing, we found that respondents could easily complete up to 15 choice tasks. The final fractional factorial design included 40 choice tasks divided among four blocks. Each respondent completed one of four surveys containing 10 choice tasks plus two common "warm up" choice tasks. Each block of choice tasks was presented in two alternative sequences to minimize order effects.

Survey administration to elicit preferences. Subjects were recruited from the Stoney Creek and Mountain Primary Care Network (PCN) in Hamilton Ontario. This PCN provides primary health-care services to patients in the region through a collaborative network of family practitioners. A random sample of 1170 patients was selected from a roster of 9959 patients aged 40 to 60 years. The family practitioners reviewed the lists to exclude those who: 1) had a history of CRC; 2) were institutionalized; 3) did not understand sufficient English; or 4) who were otherwise incapable of completing the questionnaire. The remaining patients ($n = 1047$) were assigned to receive one of eight versions of the survey (four blocks of choice tasks with two sequences).

Survey packages were marked with unique identification numbers and distributed by mail. Each package included: 1) a letter of introduction from the family physician; 2) the survey with instructions; 3) an information sheet to define medical terminology; 4) a self-addressed envelope; and 5) a $1 gift certificate. Respondents who returned surveys by a specified deadline were entered in a prize draw for dinner at a local restaurant. Following Dillman's [42] approach to enhance response rates, reminder cards were sent to nonresponders after 2 weeks, and complete survey packages were sent again after 30 days.

Following standard procedures for conjoint analysis survey administration, survey respondents were provided with 1) a description of CRC screening, the options and the risk of CRC in the general population (Appendix C); 2) a description of the decision-making situation; and 3) an example of how to complete a survey question. The patient is asked to consider a situation where their own doctor has recommended them to consider screening for colon cancer. Based on the two tests described in each question, patients are asked to select and mark the screening test that they would prefer, assuming that these are the only two options that are available to them. Furthermore, the cost attribute is explained in the context of what the patient would have to pay to have the test done.

In addition to the choice tasks, the survey inquired about demographic data such as age, sex, level of education, employment status, and household income, uptake of other cancer screening tests, and lifestyle behaviors. The survey was designed for completion within 15 min.

Respondents were almost evenly split in terms of sex (51% male) with a mean age of 50.9 years (SD = 5.96) (Table 1). The respondents in this sample were highly educated, with 93% having completed high school or a higher-level degree, 82% having an income of $30,000 or more, and most being employed full time (60%). Almost all respondents reported good or better health and only 12% reported a family history of CRC. Most had heard of FOBT (64%) and SIG (84%), but only a minority had heard of DCBE (30%) or COL (28%). Sixty-seven percent of female respondents indicated that they had undergone mammography testing to screen for breast cancer. The study population was similar in sex [43], employment status [44], and education [45] to the Canadian population based on estimates for a similar age range reported in the 2001 Statistics Canada census The annual household income more than $50,000 [46], however, was higher in the study population than the national estimates (65% vs. 42%).

Table 1 Self-reported characteristics and history of respondents (n = 547)

Characteristic	n (%)
Age (years)	
Mean	50.9
SD (minimum–maximum)	6.0 (40–61)
Sex	
Male	280 (51)
Missing	1 (<1)
Highest level of education	
Public or primary	37 (7)
High school	259 (47)
College or university	213 (39)
Graduate degree	34 (6)
Missing	4 (<1)
Annual household income in Canadian dollars ($)	
<10,000	12 (2)
10,000–29,999	62 (11)
30,000–49,999	106 (19)
50,000–69,999	123 (23)
70,000–89,999	87 (16)
90,000 or more	131 (24)
Missing	26 (5)
Current employment status	
Employed full-time	327 (60)
Employed part-time	47 (9)
Self-employed	55 (10)
Homemaker	39 (7)
Unemployed	18 (3)
Retired	57 (10)
Missing	4 (<1)
Cultural background	
North American (Canadian or American)	394 (72)
European	88 (16)
British	40 (7)
Asian	15 (3)
Caribbean	3 (1)
Other	5 (1)
Missing	2 (<1)
Health status	
Excellent	77 (14)
Very good	233 (43)
Good	181 (33)
Fair	44 (8)
Poor	11 (2)
Missing	1 (<1)
Family history of CRC	
Yes	66 (12)
Do not know	36 (7)
Missing	3 (<1)
Awareness of CRC screening modalities	
Fecal occult blood test	352 (64)
Double-contrast barium enema	164 (30)
Sigmoidoscopy	461 (84)
Colonoscopy	154 (28)

CRC, colorectal cancer.

Data analysis. Of 1047 surveys mailed, a total of 547 were returned (response rate = 52%). Results are reported for all 547 respondents, except where observations were dropped by default in the regression analyses because of missing responses.

Demographics

Respondents' demographics, health status, family history of CRC, and awareness of CRC modalities were summarized descriptively using means (SD) and ranges (minimum and maximum) for continuous variables, and number of responses (percent) for categorical variables (Table 1).

Model Estimation

Stochastic utility maximization theory provides a well-established conceptual framework for modeling individual preferences [41,47]. Random utility models were used to define the utility of choice alternatives defined as a function of the attributes. Respondent's utility or satisfaction from testing is specified as linear in test features and the utility of not testing is an alternative-specific constant:

$$V_{\text{test}} = \beta_{\text{stool}} + \beta_{\text{scope}} + \beta_{\text{CT}} + \beta_{\text{noprep}} + \beta_{\text{diet}} + \beta_{\text{nopain}} + \beta_{\text{spec=100\%}} + \beta_{\text{spec=80\%}} + \beta_{\text{sens=90\%}} + \beta_{\text{sens=70\%}} + \beta_{\text{cost}} + \varepsilon_{\text{test}} \quad (1)$$

$$V_{\text{notest}} = (\beta_{\text{o}} + \beta_{\text{age}} + \beta_{\text{male}} + \beta_{\text{college}} + \beta_{\text{income}} + \beta_{\text{healthstatus}} + \beta_{\text{crchistory}}) \times D_{\text{notest}} + \varepsilon_{\text{notest}} \quad (2)$$

The V_{test} β parameters can be interpreted as relative importance weights. Because individual-specific characteristics are constant for any pair of test alternatives, they vanish from the utility differences that determine choices among competing tests unless they are interacted with one or more test features. In this specification, we interacted several demographic and health variables (defined below) with D_{notest}, a dummy variable indicating that the respondent picked the no-test option. These parameters indicate the effect of

individual characteristics on testing uptake. The error terms ε_{test} and ε_{notest} arise because utility is stochastic from the observer's point of view [48]. We estimated the parameters using bivariate probit because the choice between two hypothetical tests followed by a test/no test choice question are correlated. We assume the variance of ε_{test} is 1, the variance of ε_{notest} is λ, and their covariance is $1/(2 \times \lambda)$.

The reference levels for each attribute were those found to be least preferred (barium enema for the process attribute, laxatives for the preparation attribute, mild pain for the pain attribute, 50% for the specificity attribute, 40% for the sensitivity attribute). Categorical test characteristics were effects coded, whereas cost was treated as a continuous variable. Standard maximum-likelihood techniques were used to estimate the parameters for this model.

We transformed the bivariate probit parameter estimates to standard logit form to facilitate calculations of uptake simulations [49]. The standard logit specification allows calculating the predicted choice probabilities for any assumed subset of tests. We can then use the estimated utility scores to calculate predicted uptake probabilities for any hypothesized set of competing tests. For example, the probability of choosing Test i when the alternatives include Test i, Test j, Test k, and No Test is [50]:

$$\text{Prob}(\text{Test i}|\text{Test i, Test j, Test k, No Test}) = \frac{\exp\left(\frac{V_{\text{Test i}}}{\lambda/1.6}\right)}{\left[\begin{array}{l}\exp\left(\frac{V_{\text{Test i}}}{\lambda/1.6}\right)+\exp\left(\frac{V_{\text{Test j}}}{\lambda/1.6}\right)+ \\ \quad \exp\left(\frac{V_{\text{Test k}}}{\lambda/1.6}\right)+\exp\left(\frac{V_{\text{No Test}}}{\lambda/1.6}\right)\end{array}\right]} \quad (3)$$

Equation 3 makes it possible to simulate how predicted uptake varies depending on which tests are available and what features the available tests have. For example, if the exponentiated utilities for alternatives i, j, k, and no test are 1, 1.5, 2.5, and 4, respectively, then the predicted uptake rate for Test i is about 0.15 if only alternatives i, j, and no test are available. However, if the more attractive test k is made available, its predicted uptake will be about 0.25 and the uptake for Test i will fall to about 0.10.

Demographic Comparisons

The following personal characteristics were included in the final regression model as categorical variables: age (>median age vs. ≤median age, median age = 51 years), sex (male vs. female), education (≥college vs. <college), annual household income (≥median income vs. <median income, median income = $60,000 CDN), self-reported health status (excellent or very good vs. good, fair or poor), and family history of CRC (relative with CRC vs. no relative with CRC).

Consistency Tests

It is important to test for consistency of responses to assess the reliability of the responses. We assessed consistency in two ways. First, individual responses were assessed for violation of the tenet of monotonic preferences, wherein individuals prefer more of any normal good [24,51]. For this purpose, the two warm-up scenarios in each choice-format stated preference survey were designed as "dominant-pair" tests where all attributes favored one alternative. Other dominant pair tests arose randomly as per the experimental design. Second, we identified respondents with preferences whose responses seem to indicate unwillingness to trade a given attribute against other attributes. A respondent was considered unwilling to trade if they made the same choices in at least 8 of 10 scenarios with that attribute. If a respondent failed either of these consistency tests, he was considered inconsistent. We ran the models both including all respondents and deleting inconsistent respondents. Coefficient signs were unaffected, and differences in the coefficients were insignificant using Wald tests ($P < 0.05$). Thus, we decided to retain all respondents in the final analysis.

Models were evaluated for goodness of fit using the likelihood ratio chi-square statistic for the global test of zero model coefficients and McFadden's pseudo R-squared. Overall, the final model fit was good (likelihood ratio chi-square statistic ($P < 0.0001$) and McFadden's pseudo R-squared = 0.1940). The modeling results are expressed as estimates, corresponding 95% confidence intervals, and P-values. All statistical analyses were performed using GAUSS version 6.0 (Aptech Systems, Inc Black Diamond, WA, USA).

The final model results were used to:

1. Evaluate the relative importance of the attributes and attribute levels. It was expected that the most important attributes would be sensitivity and specificity, followed by pain, preparation, and cost. It was predicted a priori that respondents would prefer CRC screening modalities that had high sensitivity and specificity, were noninvasive with no pain or preparation, and had a small cost.
2. Estimate the predicted choice probability of various CRC screening modalities in a scenario analysis. The predicted choice probability of commonly available CRC screening modalities (FOBT, DCBE, SIG, and COL) and two modalities that may soon be commonly available (DNA stool tests and virtual COL) was estimated using the model coefficients for attribute levels that most closely approximated those testing modalities. Although

there is a range of estimates for the accuracy [52–56], we mapped the values to the closest attribute level available in our survey to illustrate the effect on choice probabilities for the different screening modalities. The values we chose were based on cancer detection rather than polyp detection. Following standard methods for conjoint analysis, the available attribute levels in the survey are not always complete and accurate clinical descriptions of the actual CRC screening tests because of the practical limitations of the survey format. The attribute levels in the survey therefore focus on the most important features that distinguish the alternative CRC screening tests, and do not provide an exhaustive and complete description of all aspects of the tests. It was expected a priori that patients would prefer virtual COL followed by DCBE, SIG, and FOBT.

3. Estimate the percentage increase in screening uptake if alternative screening modalities were made available. We used the model to estimate expected rates of uptake for CRC screening tests that offered different mixes of alternative attributes.
4. Estimate the elasticity of uptake [57]. We estimated the elasticity of the uptake of alternative CRC screening modalities for a 1% increase in the cost of the CRC screening modality as an indication of how sensitive respondents were to changes in the price or copay.

For ease of presentation and interpretation, combined direct and interaction coefficient estimates were rescaled from 0, the least desirable attribute level, to 10, the most desirable attribute level, and presented in a figure to illustrate which attributes and levels were most important.

Results

Overall, the proportion of responses for "no CRC screening" in the second choice question in each choice task on the preference survey was 28.9%. This means that almost 30% of the time, respondents would choose not to have screening at all compared with the screening test described in the first part of the question. Respondents preferred screening processes that were noninvasive, required no preparation and involved no pain, and were highly accurate. The analysis results are further described below.

Bivariate Probit Regression Model Results (Table 2)

The parameter estimates in the main effects and interaction models were similar, except that the levels of significance changed for "scope" and "special diet." The model including interaction terms between no screening and personal characteristics provided a slightly better fit than the main effects model based on goodness-of-fit tests (Table 2). Thus, the results for the interaction model are discussed below and all subsequent analyses were based on this model.

Respondents preferred testing with a noninvasive process such as CT scan, no preparation, no pain, 100% specificity, and 90% sensitivity. In contrast, respondents preferred not to undergo testing involving barium enema, laxatives, mild pain, and with poor accuracy (50% specificity and 40% sensitivity). The attribute levels are generally well ordered and most are statistically significant (many at the alpha <0.001 level of significance). The difference in the parameter estimates between attribute levels is relatively small for some of the attributes (e.g., difference of 0.084 for preparation attribute [diet = –0.066 and laxative = –0.150] and difference of 0.017 for process attribute [stool = –0.043 and scope = –0.060]).

The parameter estimates for the personal characteristics interacted with no screening were statistically significant at the alpha = 0.05 level of significance. Respondents that were older than the median age of 51 years, female, had less than a college level of education, had an income greater than the median income of $60,000, were in poorer health, and had a family history of CRC were more likely to choose some type of CRC screening compared with no screening at all. The difference between these patient groups was greatest and statistically significant only for the parameter indicating whether or not the respondent had a family history of CRC. For all other parameters, the confidence intervals of the point estimates overlap.

CRC Screening Modality Attributes and Levels (Fig. 1)

The relative importance of the attributes and attribute levels can be observed in Figure 1 where the estimates are plotted on a scale from 0 (least desirable attribute level of 40% sensitivity) to 10 (most desirable attribute level of 90% sensitivity). For each attribute level, the point estimate and 95% confidence intervals is reported.

The most important attribute, defined as the largest absolute difference between coefficients for the highest and lowest levels, was sensitivity, followed by specificity, preparation, process, and pain. Accordingly, attributes related to accuracy (sensitivity and specificity) appear to be more important than attributes related to the modality process (preparation, process and pain). For example, the difference between no pain and mild pain is one-seventh of the difference between 90% sensitivity and 40% sensitivity.

The most preferred attribute mix is a noninvasive CT scan with no preparation, no pain, 100% specificity, and 90% sensitivity. The least preferred attribute mix was a barium contrast study enema with laxative preparation, mild pain, 50% specificity, and 40% sensitivity.

Table 2 Model results—main effects and interactions

Attribute	Level	Main effects model: Parameter estimate All observations n = 541; 10,440 observations	*P*-value	Main effects model and interactions: Parameter estimate All observations n = 541; 9920 observations	*P*-value
Process	CT scan	0.226	‡	0.229	‡
	Stool	–0.030	§	–0.043	§
	Scope	–0.071	†	–0.060	*
	Barium enema‖	–0.125	§	–0.126	§
Preparation	None	0.223	‡	0.216	‡
	Special diet	–0.069	‡	–0.066	†
	Laxatives‖	–0.154	‡	–0.150	‡
Pain	None	0.100	‡	0.095	‡
	Mild pain‖	–0.100	‡	–0.095	‡
Specificity	100%	0.296	‡	0.290	‡
	80%	–0.018	§	–0.011	§
	50%‖	–0.278	‡	–0.279	‡
Sensitivity	90%	0.729	‡	0.730	‡
	70%	0.028	§	0.035	§
	40%‖	–0.757	‡	–0.765	‡
No CRC screening		–2.240	‡	–1.977	‡
Ln (LAM)		4.487	‡	4.261	‡
CRC modality cost		–0.002	‡	–0.002	‡
Interaction terms—personal characteristics with no screening					
Age greater than median				–0.6842	†
Male				0.6909	†
College degree or higher				0.5425	†
Income greater than median				–1.0091	†
Self-reported health very good or better				0.5322	*
Self-reported health good				0.2853	§
Has relative with CRC				–2.484	‡
Model goodness of fit statistics					
–2 log likelihood ratio full		11007	§	10298	§
–2 log likelihood ratio restricted		13459	§	12776	§
Likelihood ratio χ^2		2452	‡	2478	‡
Degrees of freedom		12	§	19	§
McFadden's Pseudo-R^2		0.1822	§	0.1940	§

*$P \leq 0.05$, †$P < 0.01$, ‡$P < 0.001$, §$P > 0.05$.
‖Reference level.

Predicted Choice Probability for Alternative CRC Screening Modalities (Fig. 2)

Using the interaction model results, the choice probability of current and emerging CRC screening modalities were estimated in scenario analyses and are shown in Figure 2. Each CRC screening modality was represented by the attribute levels that most closely approximated the actual values of that test. Based on this, virtual COL is the most preferred CRC screening test, followed by COL, DCBE, SIG, fecal DNA testing, and finally, FOBT. This fits with a priori expectations. The ordering of preference for the alternative CRC screening modalities is driven primarily by the estimates of accuracy (sensitivity and specificity).

Estimates of CRC Screening Uptake (Table 3)

The model results were used to examine policy relevant scenarios and predict the expected rates of uptake for CRC screening programs that offered different mixes of alternative CRC screening modalities. Assuming that CRC screening uptake would be 30% if FOBT was the only screening test available, adding one of the other screening tests would increase uptake 24% to 30% (Table 3). The greatest impact on screening uptake, a 42% relative increase, would be achieved if all common approaches for CRC screening were made available (FOBT, DCBE, SIG, and COL). Nonetheless, for no combination of modalities is the predicted absolute uptake rate greater than 42%. If all common approaches for CRC screening were available, and virtual COL or fecal DNA were introduced, the increment in CRC screening uptake would be minimal, approximately 2%.

Estimates of Elasticity (Table 4)

The parameter for modality cost was negative, and statistically significant (alpha < 0.001). This indicates that respondents paid attention to cost in evaluating modality options.

Although the parameter estimate is statistically significant, its effect on uptake is very small. For all the scenarios examined, the uptake of CRC screening is almost perfectly inelastic (Table 4). The largest decrease in the quantity of CRC screening demanded

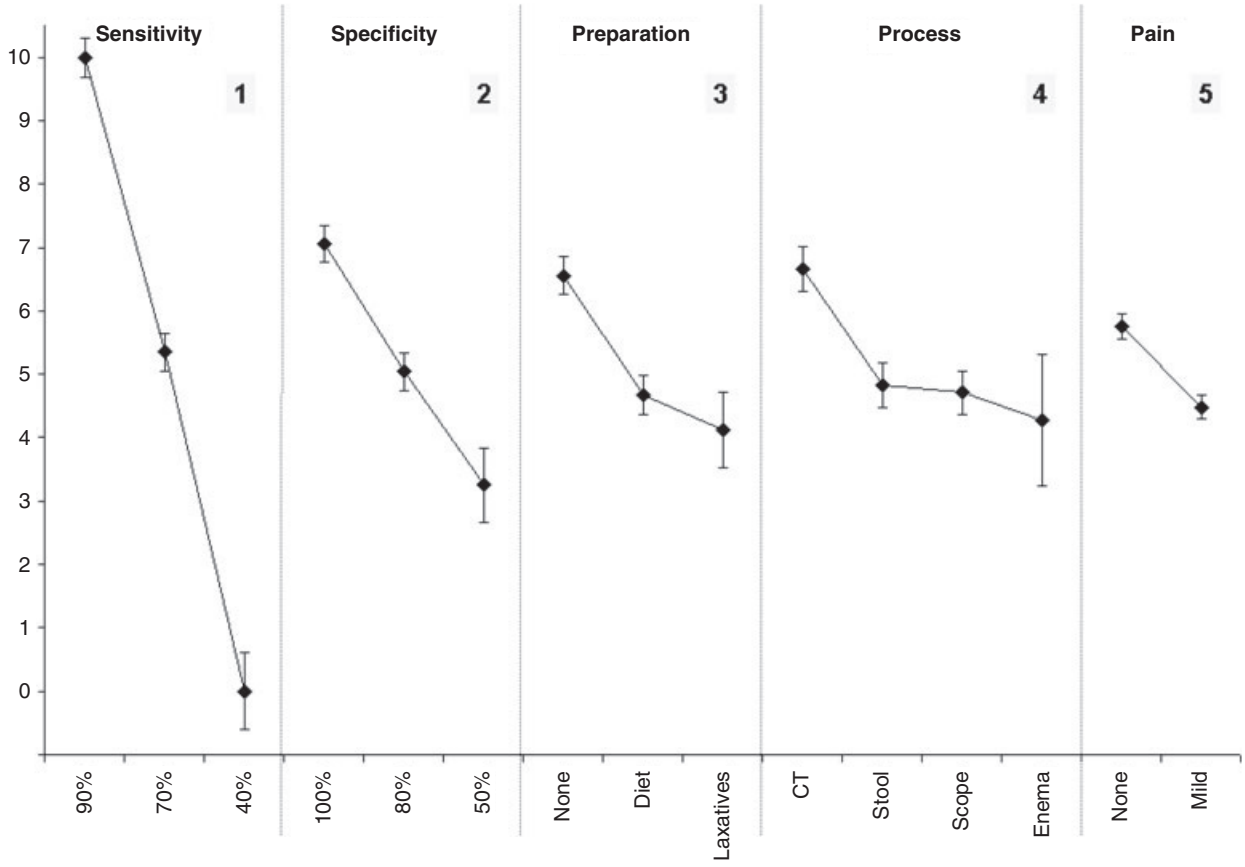


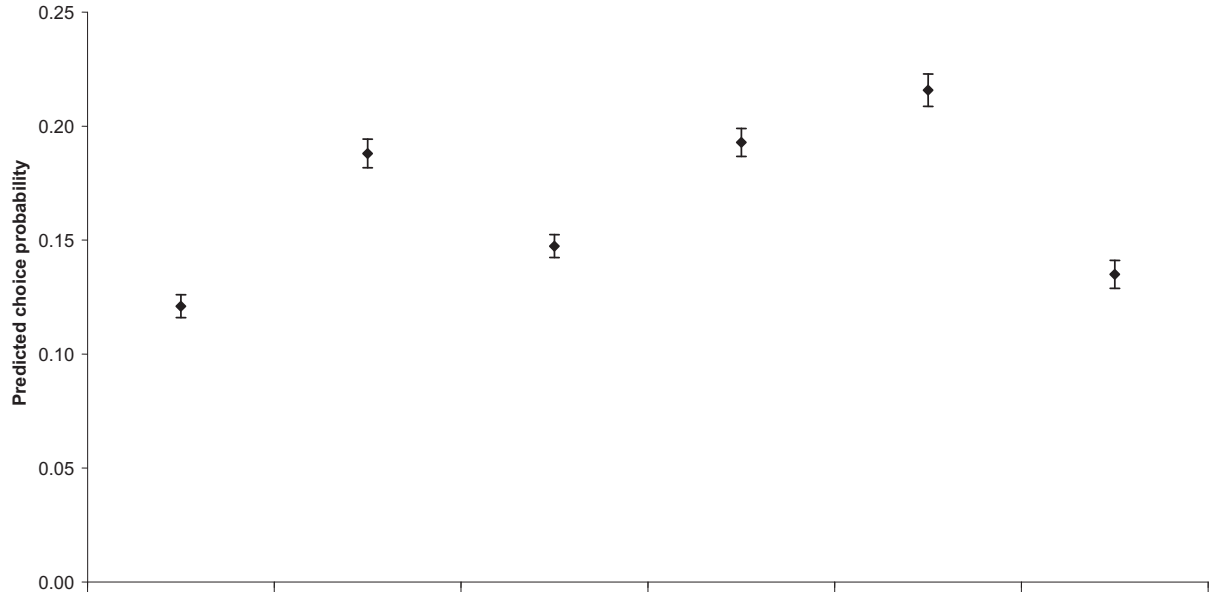
Figure 1 Relative importance of colorectal cancer screening modality attributes and attribute levels. Parameter estimates of all attribute levels rescaled from 0 to 10 and grouped by attribute to illustrate: 1) Relative importance of attributes (numbered from 1 to 5). The more critical the attribute in modality uptake, the farther apart the parameter values. 2) Relative preference of levels of each attribute. Higher values indicate that the attribute level is preferred.

occurs with an increase in the cost of virtual COL in the scenario where virtual COL and FOBT are the available modalities—a 10% increase in the price would decrease screening uptake by only 0.37%.

Discussion

To our knowledge, this is the first study to use a theoretically based and statistically rigorous approach to measure preferences for CRC screening methods in Canada. The question remains as to the most appropriate CRC screening method from among the existing alternatives [58]. The results of this study identify substantial differences in the importance of various CRC screening test attributes. We found that the respondents value attributes related to accuracy (sensitivity and specificity) more than those related to the testing process (preparation, process, and pain). The literature on relative preferences for CRC screening alternatives is limited. Most studies have used qualitative survey methods to determine the proportion of patients who prefer alternative CRC tests, often limited to two choices, and to identify the most important test feature in selecting a screening method [14,59]. Our findings are consistent with the general findings from previous studies that examined patient choices among CRC modalities qualitatively [14,60–63]. Other nonutility based studies on patient preferences for alternative CRC screening modalities have observed heterogeneity in individual patient preferences by patient characteristics and reported that preferences vary depending on how patients value different test features. Nonetheless, the findings have been reasonably consistent about preferences for CRC screening tests with high accuracy [59,64–66]. These studies are limited however, because they do not reflect patients underlying utility values. To measure utilities, the survey must be designed in a format that requires respondents to trade-off among alternative choices. This can be achieved using a choice-based stated preference survey, as we did in this study, which permits a quantitative understanding of the relationship among the features of CRC screening tests.

Among CRC screening modalities currently endorsed by agencies such as the Canadian Task Force on Preventive Care [67], the American Cancer Society



	FOBT	DCBE	SIG	COL	VCOL	DNA
Process	Stool	Enema & xray	Scope	Scope	CT	Stool
Pain	None	Mild	Mild	Mild	Mild	None
Preparation	Diet	Enem/lax	Enem/lax	Enem/lax	Enem/lax	None
Specificity	100%	100%	100%	100%	100%	100%
Sensitivity	40%	90%	70%	90%	90%	40%

Figure 2 Predicted choice probabilities for alternative colorectal cancer screening modalities. COL, colonoscopy; DCBE, double-contrast barium enema; DNA, fecal DNA; FOBT, fecal occult blood test; SIG, secigmoidoscopy; VCOL, virtual colonoscopy.

[68] and the US Preventive Services Task Force for CRC screening [69], respondent preference for accuracy was the main reason why COL was most preferred and FOBT was least preferred. These scenario analyses provide an estimate of preferences based on assumptions about the attribute levels for each screening modality. Recognizing that the estimates for the performance of each of these tests vary considerably depending on the technology and generally do not represent performance in the context of a population screening program, we examined alternative estimates in sensitivity analyses. For example, FOBT specificity for the current rehydrated assays has been reported as high as 97% [56]. Even in this scenario, the overall results and conclusions about the choice probabilities for alternative CRC screening modalities are robust.

Among emerging CRC screening modalities, we found that virtual COL, as represented by the attribute levels in this survey, was preferred to fecal DNA assays [52,70] and we found that virtual COL would be the

Table 3 Estimates of CRC screening uptake

Menu 1		Menu 2		
Modalities available	Baseline rate of screening uptake	Additional modalities available	New rate of screening uptake	% Increase in screening uptake: menu 2 vs. menu 1
FOBT	0.300	VCOL	0.391	30
FOBT	0.300	SIG	0.375	25
FOBT	0.300	COL	0.386	29
FOBT	0.300	DCBE	0.385	28
FOBT	0.300	Fecal DNA	0.371	24
FOBT, DCBE, SIG, COL	0.300	VCOL	0.307	2
FOBT, DCBE, SIG, COL	0.300	Fecal DNA	0.305	2
FOBT	0.300	DCBE, SIG, COL	0.425	42

COL, colonoscopy; DCBE, double-contrast barium enema; FOBT, fecal occult blood test; SIG, secigmoidoscopy; VCOL, virtual colonoscopy.

Table 4 Modality cost elasticity estimates

New modality	FOBT + new modality Elasticity (95% confidence interval)	FOBT + DCBE + SIG + COL + new modality Elasticity (95% confidence interval)
DCBE	−0.011 (−0.014 to −0.012)	NA
SIG	−0.012 (−0.016 to −0.009)	NA
COL	−0.027 (−0.035 to −0.026)	NA
VCOL	−0.037 (−0.048 to −0.021)	−0.006 (−0.01 to −0.003)
DNA	−0.018 (−0.026 to −0.016)	−0.002 (−0.002 to −0.003)

COL, colonoscopy; DCBE, double-contrast barium enema; DNA, fecal DNA; FOBT, fecal occult blood test; NA, not applicable; SIG, sigmoidoscopy; VCOL, virtual colonoscopy.

most preferred of all CRC screening modalities. It is notable that although other CRC screening modalities are reimbursed, virtual COL is not reimbursed for screening in the United States.

Our study also adds to the literature by using an "opt-out" follow-up question format, a methodological advance that allowed us to estimate the probability of choosing no screening and infer rates of screening uptake from the results. This format forced respondents to first choose among two CRC screening modality scenarios presented, and then choose between the selected screening modality and the option of no CRC screening. To our knowledge, this approach has been not been used in other preference studies of screening.

In the context of considering CRC screening in Canada, it is important to recognize that some proportion of people will not get screened regardless of the testing alternatives. Despite the prospect of reduced CRC mortality, a significant challenge to the uptake of CRC screening is overcoming public lack of acceptance of the screening procedures [71]. Low screening uptake is multifactorial, based not only on patient preferences, but also physician preferences. A positive attitude toward screening and physician recommendation result in high adherence whereas fear of finding cancer and the belief that cancer is fatal result in low adherence [72]. Previous research has shown that the general practitioner is an important influence in the decision to undergo CRC screening [65]. Because FOBT is currently being pilot tested and recommended for CRC screening in Canada, we examined the impact of making other CRC screening modalities available in addition to FOBT. Not surprisingly, our results suggest that the greatest impact on screening uptake, a 50% increase to achieve a screening uptake rate of 45%, would be achieved if all commonly available and endorsed CRC screening modalities were made available, and that the addition of virtual COL or fecal DNA to an existing menu of CRC screening modalities would only have a minimal impact on screening uptake of approximately 2%. Although not everyone will participate in screening, there is an opportunity to increase screening uptake rates by offering a reasonable range of CRC screening modality options, instead of limiting the choice to FOBT. Based on our projections, it is not unreasonable to hypothesize that rates could be increased to those observed in the United States of approximately 50%. The impact of increased CRC screening to decrease the incidence of CRC could be significant, based on the findings of the National Polyp Study that CRC incidence was 76% lower in those who had a polypectomy after a COL than the general population [73].

The results of this study must be interpreted with caution, particularly in the context of applying the results to preferences for CRC screening programs. To make the survey tractable, the attribute descriptions to depict the CRC screening tests were simplified. For example, the process attribute was deliberately simplified to focus on the aspects of the testing process that distinguishes each of the CRC screening test modalities from another. Secondly, the number of attributes for the process attribute was reduced to four instead of five to simplify the methodological design. The consequence of this is that COL and SIG, as represented in these analyses, only differ in their sensitivity estimates. Furthermore, this survey specifically focused on the uptake of a single CRC cancer screening test, not an entire screening program that involves a series of screening tests implemented over time. This study focuses on patient preferences for uptake of CRC screening based on attributes of the CRC screening tests. In addition to the simplifications of the survey design and format to make it a practical instrument for administration, the results may be limited in terms of their generalizability. Given that the survey response rate was 52%, the validity of the findings may be affected by respondent selection bias and it is not obvious how this would affect preference estimates for CRC screening tests. We were not able to collect demographic information on nonresponders to determine whether there were systematic differences between responders and nonresponders.

This study supports the feasibility and usefulness of choice-format stated preference methods in health services evaluation, which is consistent with positive findings reported by others for different diseases [27, 74–77]. Respondents found the survey feasible to complete, based on the response rate and level of completion, consistency tests showed that respondents were considering trade-offs between attributes, and the attribute levels were ordered and demonstrated prefer-

ence patterns with face validity and in line with a priori hypotheses. Choice-format stated preference methods are particularly appropriate when it is important to quantify relative preferences for specific attributes, including aspects of both process and outcome, of a service or technology. CRC screening is a particularly relevant application because there are multiple screening strategies available that differ substantially with regard to the process, preparation, and recommended frequency of testing. Our findings emphasize the important role of patient preferences in CRC screening [12,13]—we found that accuracy as measured by sensitivity and specificity is substantially more important than process-related features and there is considerable diversity in preferences of demographic subgroups in the population. In this article, we adopted a public health perspective to examine how overall population uptake is affected by the features and availability of CRC screening test modalities. Further research is warranted to examine the role of patient preferences for other attributes of the CRC program beyond the uptake of the initial CRC screening test. The clinical assessment of risk in determining which tests are appropriate for individual patients is also an important consideration.

These study results are timely for Canadian health policy because formal CRC screening programs have not been implemented in Canada. FOBT, to the exclusion of alternative CRC screening modalities, has been recommended by the National Committee on CRC Screening for CRC screening programs [71] because FOBT is the only modality with randomized clinical trial data showing a reduction in mortality [78–81]. CRC screening with FOBT is currently the only approach being evaluated in a pilot test program in Ontario [7] because data from randomized clinical trials are limited to CRC screening with FOBT [79–81]. However, FOBT is the least preferred CRC screening modality among the alternatives. Thus, our findings are relevant in the context of understanding patient decisions about the uptake of CRC screening and may help to inform health policy about CRC screening programs.

What are the implications of this study for developing and targeting future CRC screening modalities, particularly as they extend beyond the Canadian context? The results from choice-format stated preference surveys can also be used to estimate preferences for services or technologies that are not currently available. For example, although the performance of virtual COL in clinical practice remains controversial [52,70], it is less invasive than conventional COL. Our findings suggest that virtual COL would be preferred over all existing CRC screening modalities. Fecal DNA assays been suggested to offer a high specificity of almost 100% but only a modest sensitivity of approximately 50% [37] and would not be preferred over existing alternatives except FOBT. Focusing exclusively on FOBT may not be the optimal approach to implementation of CRC screening in Canada. We also found that providing a range of screening options is most likely to increase utilization—an important lesson for screening programs in other countries as well. In conclusion, the results of this study suggest that there is a need to consider patient preferences and diversity to optimize uptake of CRC screening.

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Appendix A. Attributes and Levels Used in the Stated Preference Survey

Attributes	Attribute description as presented to patients	Levels	Level description as presented to patients
Process	How is it done?	Stool	You place 2 stool samples onto special cards for 3 consecutive days and return them to your doctor
		Scope	A flexible tube with a small camera at the tip is inserted into your rectum and through your colon
		CT	You lie on a special table while a machine moves around you and takes x-ray pictures (like a CAT scan)
		Enema and X-ray	Air and a white liquid are injected into your colon through a rectal tube. x-ray pictures are taken as the liquid moves through your colon*
Pain	Is there pain or discomfort?	None	You feel no pain during the test
		Mild	You may feel mild pain or discomfort during the test*
Preparation	What do you do to prepare?	None	No preparation required
		Diet	You must alter your diet for 5 days by avoiding some specific foods and over-the-counter medications
		Enem/lax	Before the test you must take laxatives or enemas which cause diarrhea to clean your colon*
Specificity	Is it accurate if you DO NOT have cancer?	100%	If you DO NOT have cancer, the test result will never say you may have cancer. No other test is needed.
		80%	If you DO NOT have cancer, the test result will say you may have cancer 2 out of 10 times. You then need to have a different test done
		50%	If you DO NOT have cancer, the test result will say you may have cancer 5 out of 10 times. You then need to have a different test done.*
Sensitivity	Is it accurate if you DO have cancer?	90%	If you DO have cancer, the test will miss it 1 out of 10 times
		70%	If you DO have cancer, the test will miss it 3 out of 10 times
		40%	If you DO have cancer, the test will miss it 6 out of 10 times*
Cost	How much would you pay?	$10	$10
		$50	$50
		$250	$250
		$500	$500

*Reference level for attribute.

Appendix B. Survey Preamble and Example of Stated Preference Survey Choice Task

Doctors may recommend that their patients consider screening for colon cancer. Suppose your own doctor recommended this for you.

The first part of this survey has 12 questions. In each question there are two tests, Test A and Test B, which are ways to screen for colon cancer. Please mark the test you would prefer. Some of the tests shown are not available now, but could be available in the future. **When you answer each question, imagine that the options shown are the only ones available to you.**

Each test includes a cost. Please ASSUME THAT THIS IS WHAT YOU WOULD HAVE TO PAY TO HAVE THE TEST DONE, and that YOU WOULD *NOT* LOSE INCOME IF YOU MISS TIME FROM WORK. Depending on your situation this COST could include costs for any of the following:

- medication;
- materials to prepare for the test (e.g., laxatives or enemas);
- child care;
- transportation to go to the hospital or doctor's office (e.g., parking, gas, taxi).

PLEASE ASSUME THAT NONE OF THESE COSTS ARE COVERED by the government or your private insurance.

When comparing the different colon cancer screening tests, please consider how their associated costs would affect your household budget. For example, paying $75 means that you have $75 less to spend on something else.

The following table shows an example question.

Features	Test A	Test B
How is it done?	You place 2 stool samples onto special cards for 3 consecutive days and return them to your doctor	A flexible tube with a small camera at the tip is inserted into your rectum and through your colon
Is there pain or discomfort?	You feel no pain during the test	You may feel mild pain or discomfort during the test
What do you do to prepare?	You must alter your diet for 5 days by avoiding some specific foods and over-the-counter medications	Before the test you must take laxatives or enemas which cause diarrhea to clean your colon
Is it accurate if you DO NOT have cancer?	If you DO NOT have cancer, the test result will say you may have cancer 5 out of 10 times. You then need to have a different test done	Same as for Test A
Is it accurate if you DO have cancer?	If you DO have cancer, the test will miss it 3 out of 10 times	Same as for Test A
How much would you pay?	$50	$250
Which test would you prefer (please mark one box only)	Prefer A ☐	Prefer B ☐
Suppose you now have the option of no screening. What would you prefer now? (please mark one box only)	I would still prefer the test chosen above	☐
	I would prefer no screening	☐

The first part of the question shows two ways to screen for colon cancer and asks which you would prefer. In this case, the person indicated that he/she preferred Test A over Test B. ***Even if you do not like either test, please mark the one you would prefer if you had to choose one.***
The second part of the question asks if you would still prefer screening if you had the option of no screening. In this case the person indicated he/she would prefer no screening. **There is no right answer. We are interested in your preferences.**

Appendix C. Words and Their Meanings

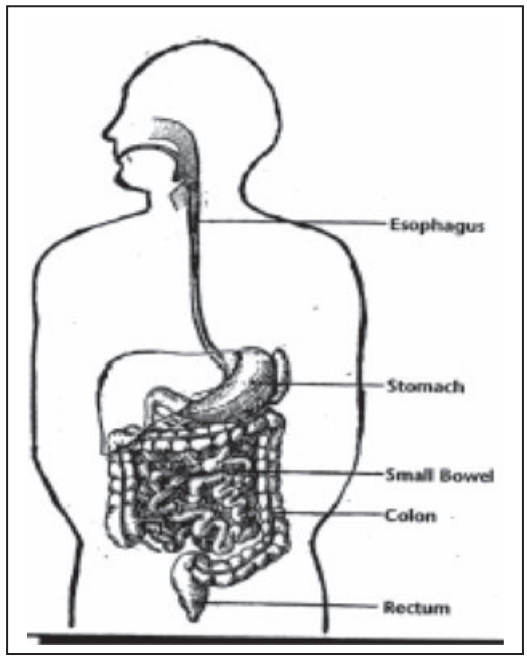
Colon cancer is a disease that can affect your colon or rectum. Colon cancer is as common in men as it is in women. In 1998, 6500 Ontarians received a diagnosis of colon cancer and 2200 people died of the disease. It is the third leading cancer killer in North America.

This survey asks about colon cancer screening. Screening means testing for cancer even when you have NO problems or symptoms and everything is working FINE. Screening for cancer may find cancer or precancerous growths (polyps) when they are much easier to treat and more likely to be cured.

There are many ways to screen for colon cancer. For example, one way involves taking stool samples with a kit and sending them to a lab. Others are done at your doctor's office or in a hospital where the inside of the colon and rectum is examined with special cameras or x-rays.

In this survey you may find words you do not understand. The following table explains some of these words. **You can refer to this table as you answer the survey.**

Diagram: Digestive System



Word	Meaning
1. Cancer	A disease where cells in one part of the body grow much more than normal.
2. CAT scan or CT scan	A special x-ray test, where you lie on a table that moves through a ring. A camera spins around inside the ring and takes x-ray pictures.
3. Colon	The colon is the lower part of your intestine (see diagram). It is also called the large intestine or bowel.
4. Enema	A liquid that is inserted into the rectum to clean the lower part of the bowel.
5. Laxative	A medicine that you take by mouth to make your bowels move. Some laxatives cause diarrhea.
6. Mammogram	A test where x-rays are taken of your breasts.
7. Polyp	A growth on the lining of the colon (see diagram) that could turn into cancer if it is not removed.
8. Rectum	The rectum is the last part of your colon (see diagram).
9. Stool	Product of bowel movement.